US009149902B2

(12) **United States Patent**
DeCore et al.

(10) **Patent No.: US 9,149,902 B2**
(45) **Date of Patent: Oct. 6, 2015**

(54) **SLUG RETENTION GROOVE FORMING MACHINE AND METHOD**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 60 days.

(21) Appl. No.: **13/828,399**

(22) Filed: **Mar. 14, 2013**

(65) **Prior Publication Data**

US 2013/0252517 A1 Sep. 26, 2013

Related U.S. Application Data

(60) Provisional application No. 61/612,226, filed on Mar. 16, 2012.

(51) **Int. Cl.**
B24B 19/20 (2006.01)
B24B 23/02 (2006.01)

(52) **U.S. Cl.**
CPC ***B24B 19/20*** (2013.01); ***B24B 23/026*** (2013.01)

(58) **Field of Classification Search**
CPC B24B 19/20; B24B 23/026; B24B 23/00; B24B 23/08
USPC 451/344, 340, 363, 358, 294, 295, 231, 451/233, 439
See application file for complete search history.

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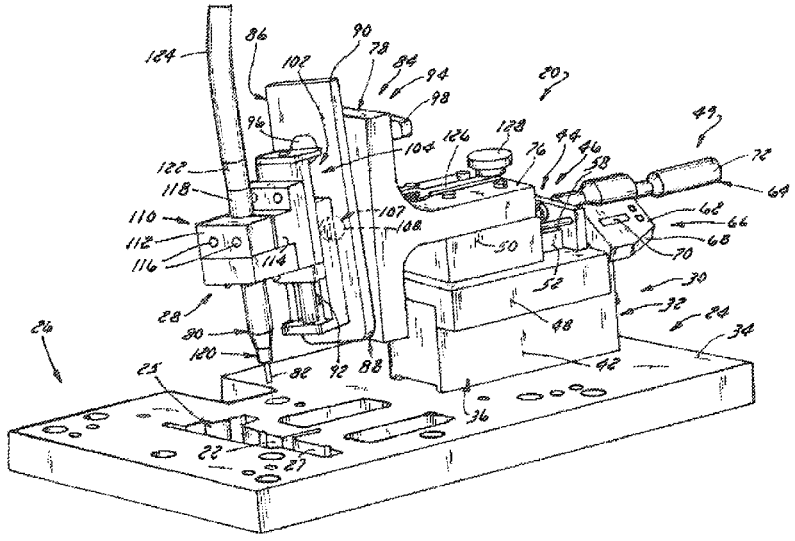
(74) *Attorney, Agent, or Firm* — Boyle Fredrickson S.C.

(57) **ABSTRACT**

A portable and transportable die cavity modifying machine having a base carrying a carriage adjustable along one axis, e.g., a generally horizontal axis, and a machining head adjustable along another axis, e.g., a generally vertical axis, for modifying a die cavity of a stamping die in a manner that prevents blank or slug pulling during stamping press operation. The machine includes a grinder that can be pneumatically powered having a grinding bit used to precisely machine a slug retention groove in a die cavity defining surface (sidewall) of a die cavity formed in a stamping die. The machine has an angularly adjustable head carrying the grinder enabling adjustment of the angle of the groove relative to die cavity defining surface enabling the groove to be angled relative to the direction of a punch entering the die cavity during stamping.

32 Claims, 12 Drawing Sheets



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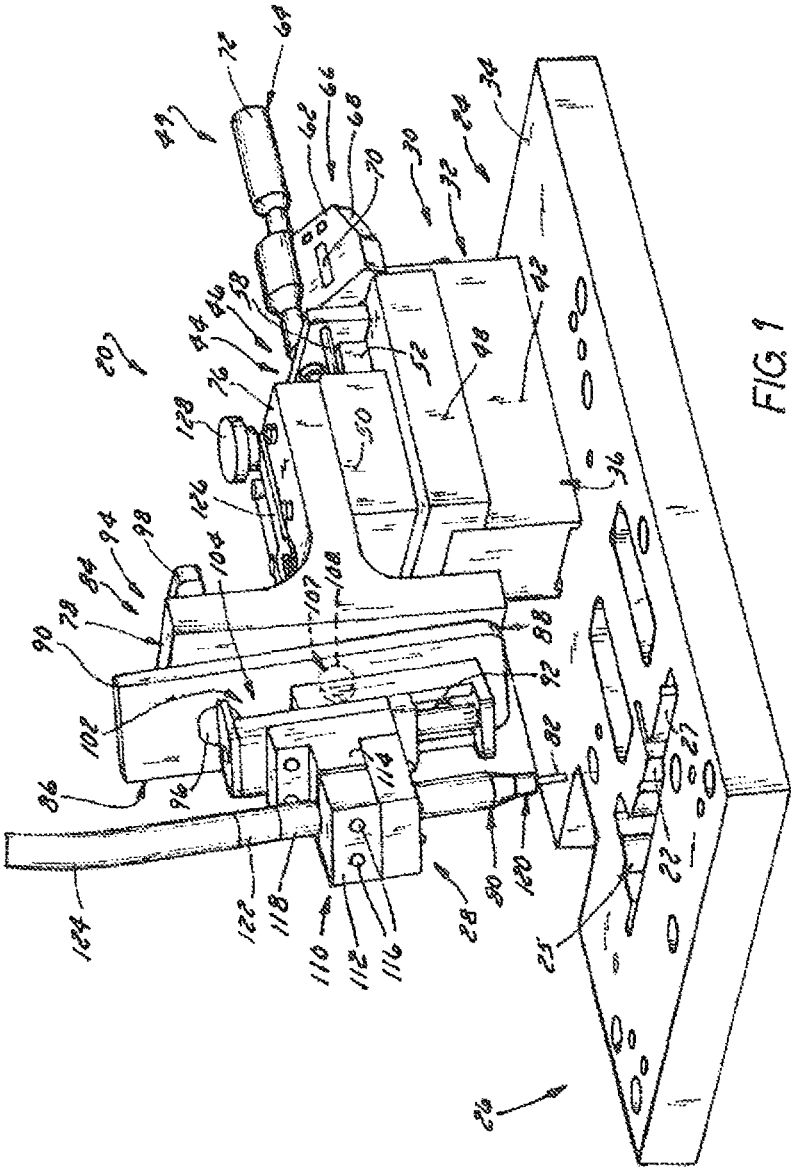

FIG. 1

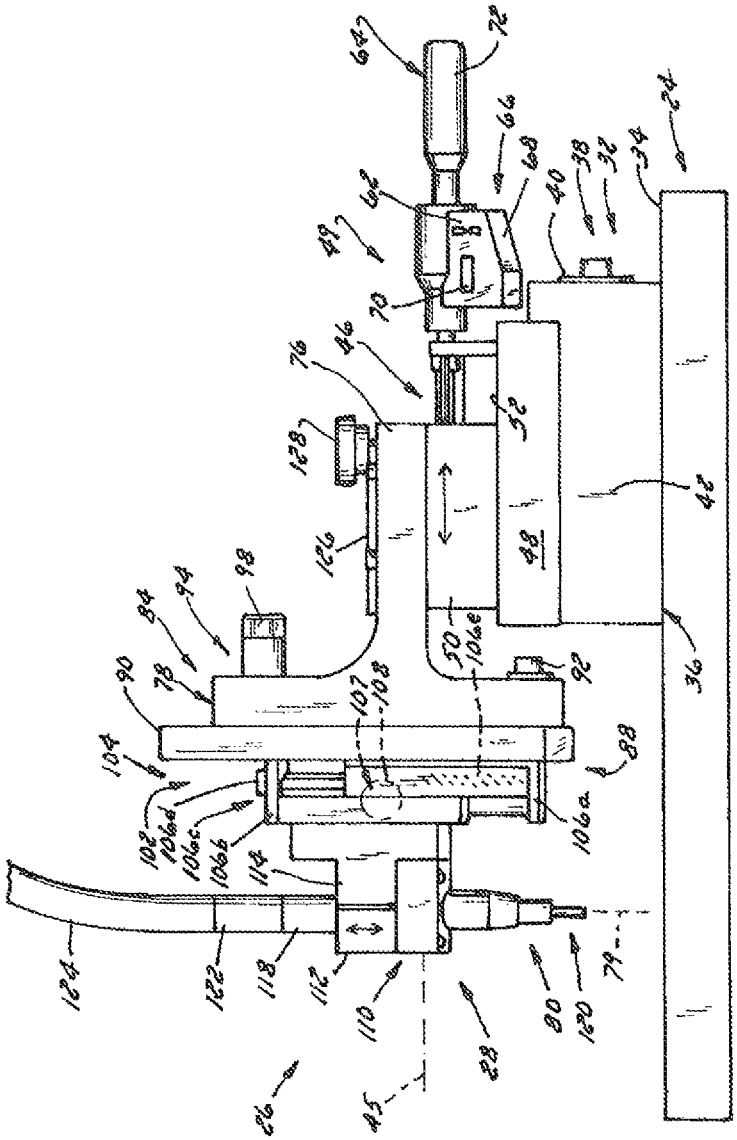

FIG. 2

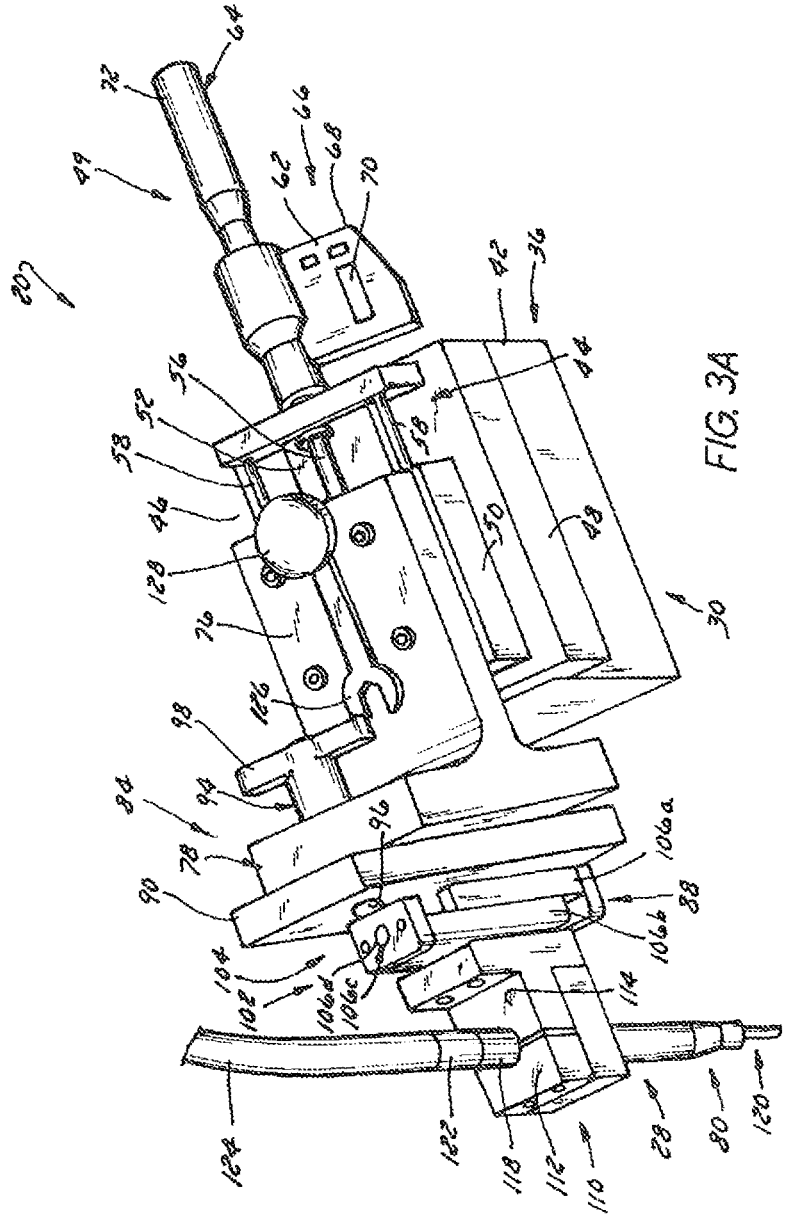
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FIG. 3A

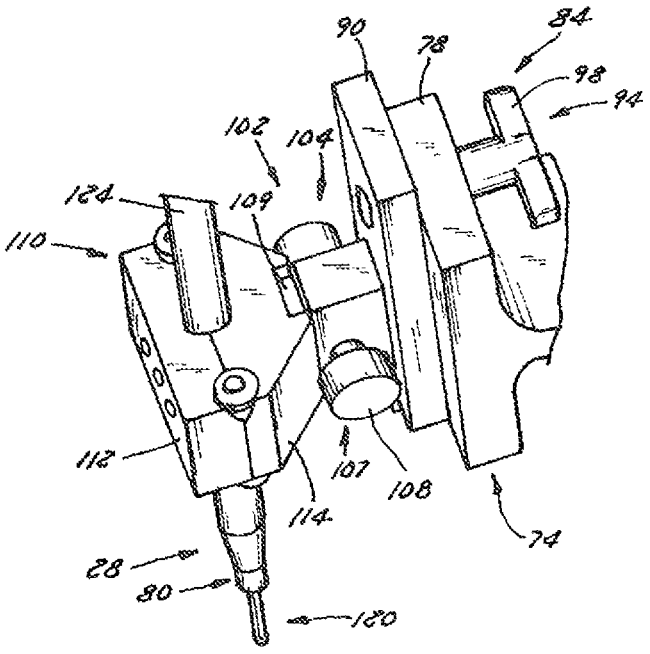

FIG. 3B

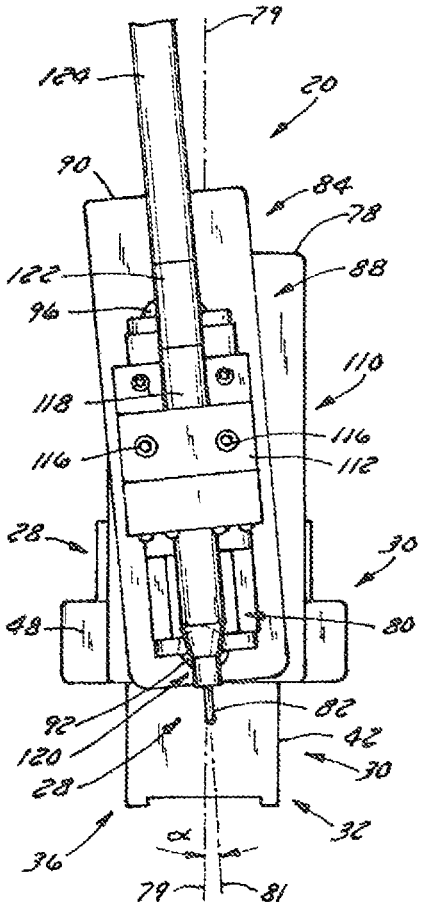
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FIG. 4

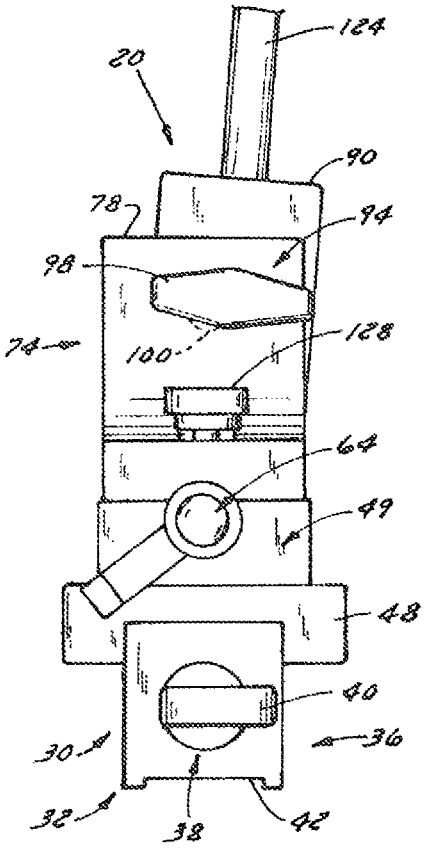
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FIG. 5

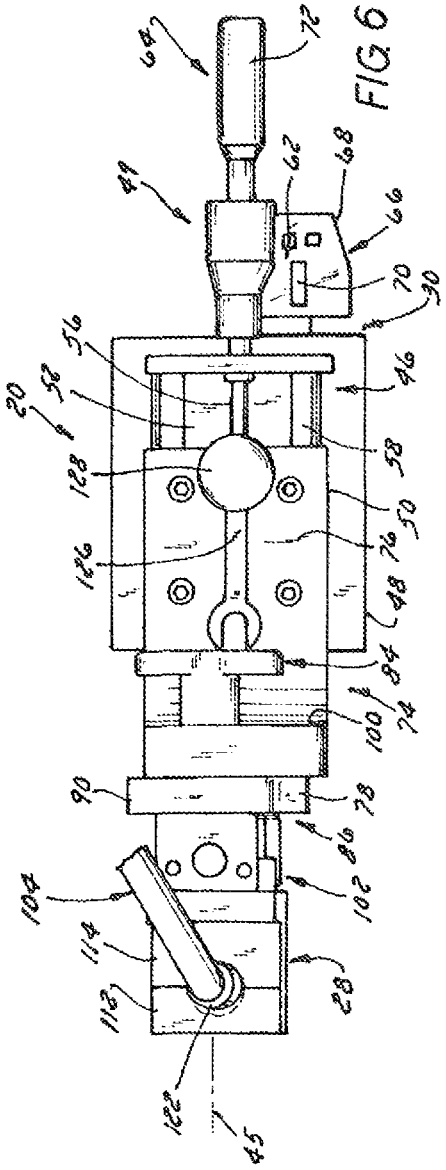

FIG. 6

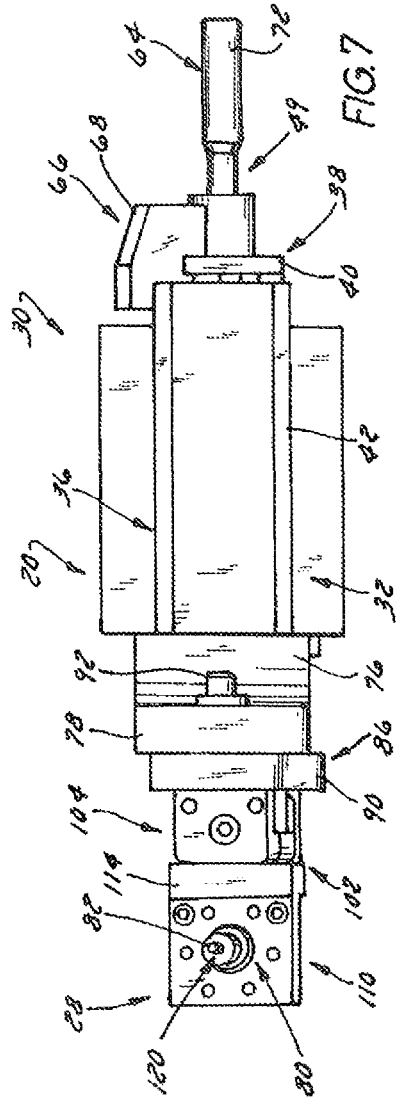

FIG. 7

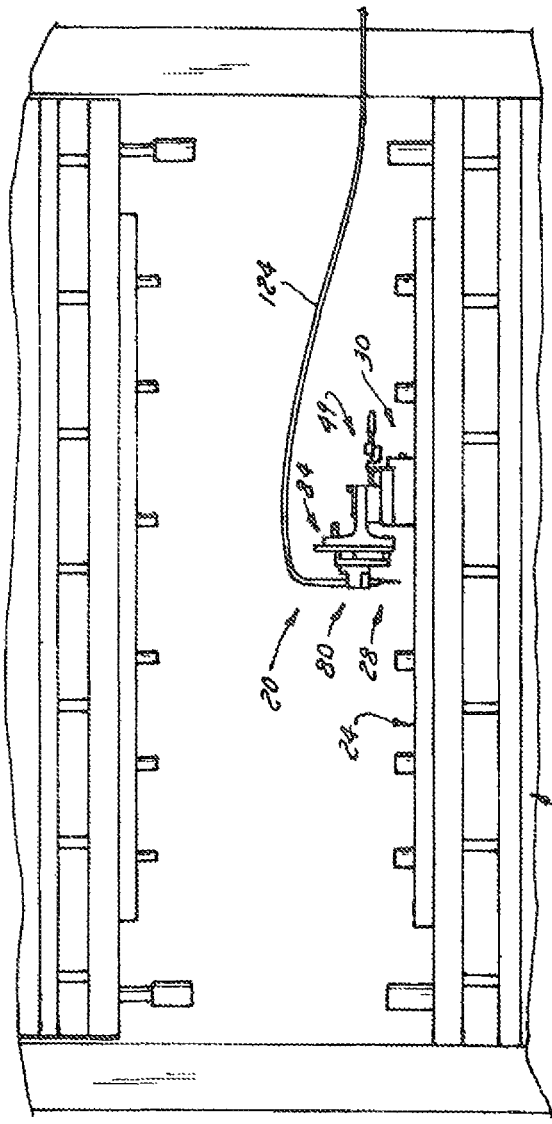

FIG. 8

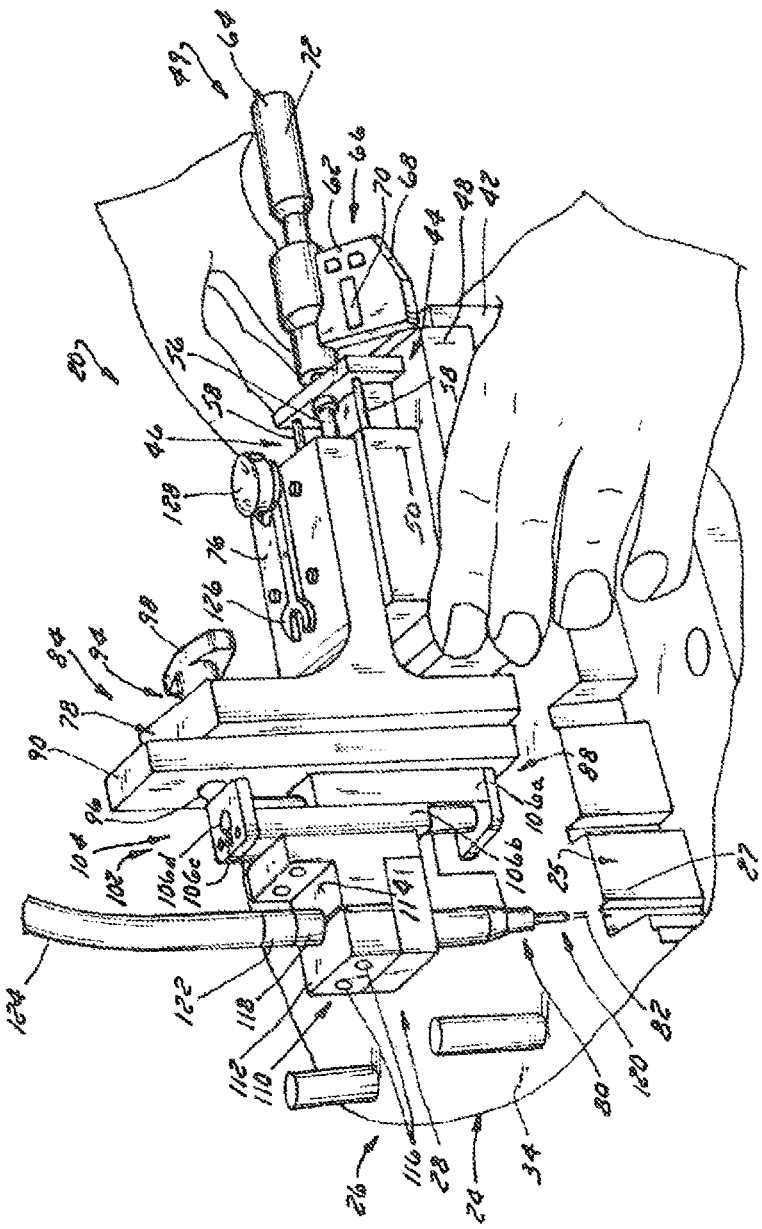

FIG. 9

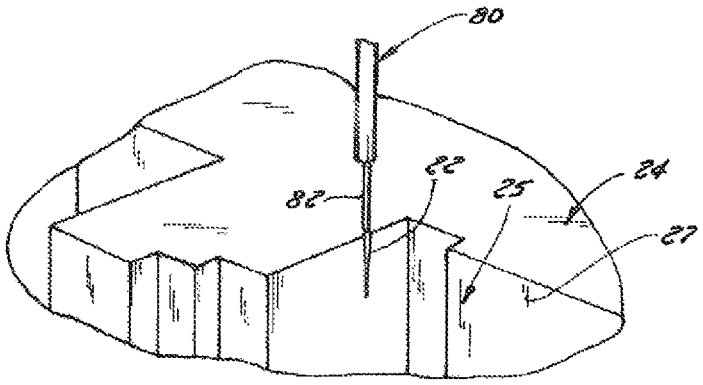

FIG. 10

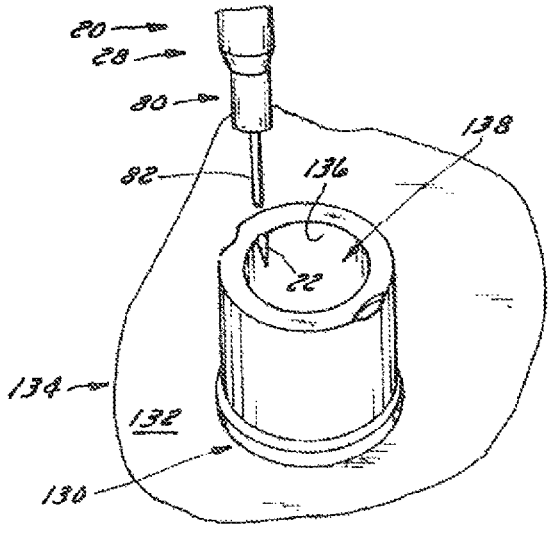

FIG. 11

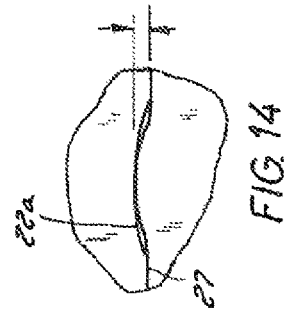

FIG. 14

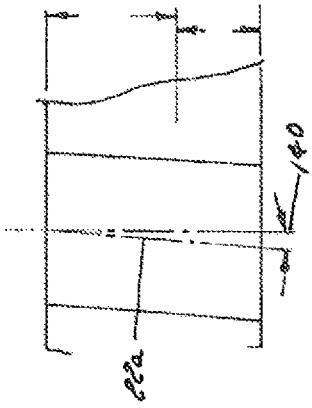

FIG. 15

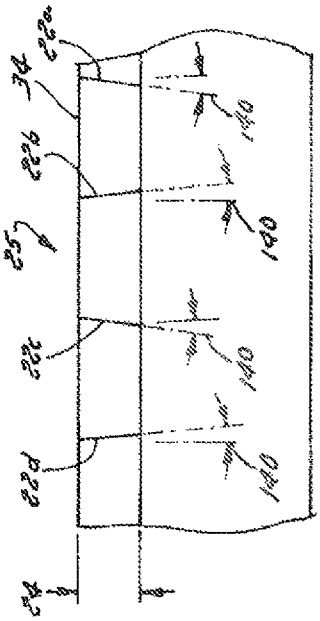

FIG. 12

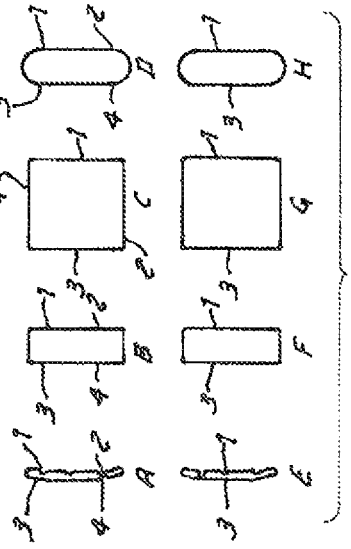

FIG. 13

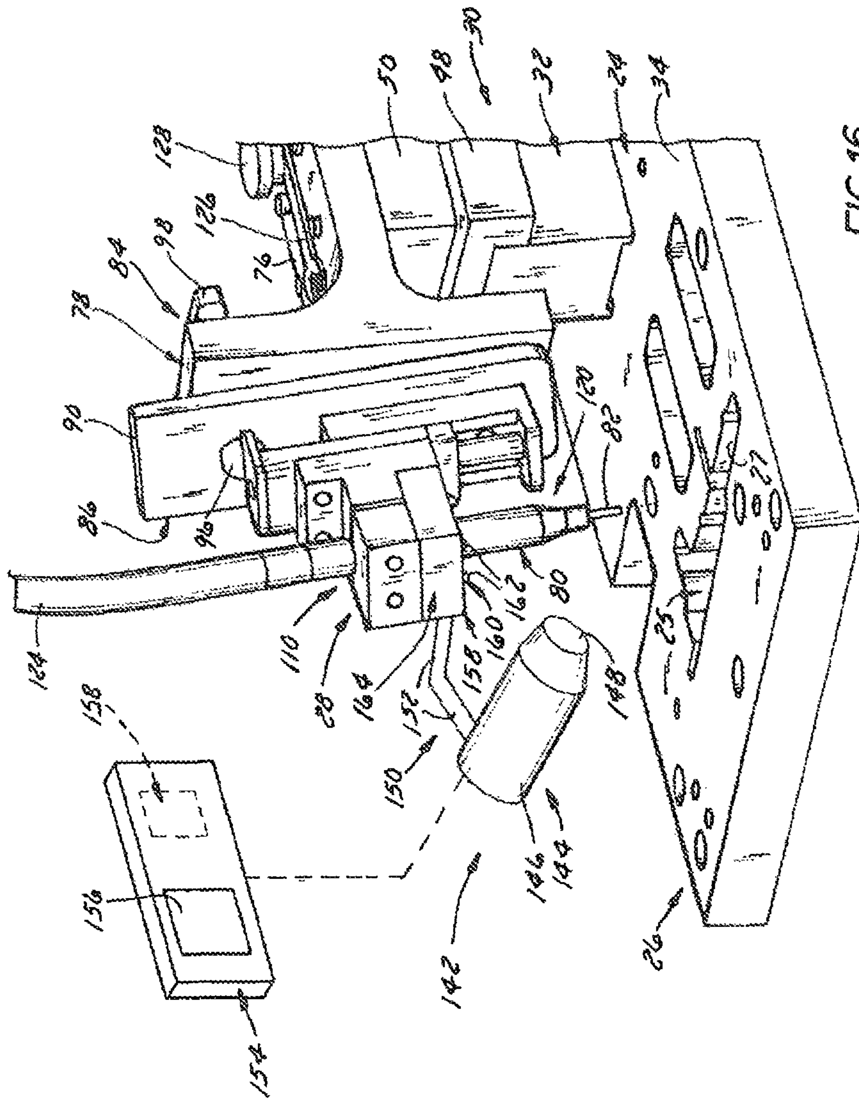

FIG. 16

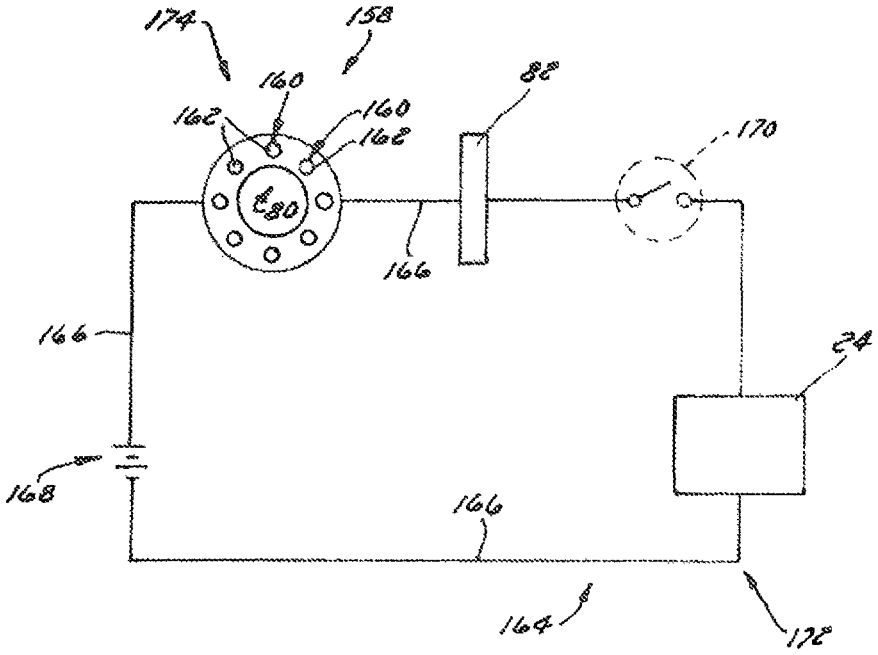

FIG. 17

SLUG RETENTION GROOVE FORMING MACHINE AND METHOD

CROSS REFERENCE

This application claims priority under 35 U.S.C. §119(e) to U.S. Provisional Patent Application No. 61/612,226, filed Mar. 16, 2012, which is expressly incorporated by reference herein

FIELD

The present invention relates generally to a machine and method for modifying a cavity of a die to retain slugs or blanks within the die cavity so the slug or blank does not pull out of the die during stamping operation. In a preferred embodiment, the present invention is directed to a portable and transportable slug retention groove forming machine, a "slug keeper" machine, used to machine slug keeper grooves in the sidewall of a die cavity or die opening of a die even while the die is still in the stamping press.

BACKGROUND

During metal stamping, a sheet of metal is positioned over a die opening or die cavity before a punch is rapidly pushed through the sheet into the die opening or cavity of cutting a blank or slug from the sheet having substantially the same shape or contour as the profile of the die cavity. Particularly, where the blank or slug is intended to be pushed through the die cavity, retraction of the punch can cause the blank or slug to undesirably pull out of the die.

To prevent circular blanks or slugs from pulling out of the die, Kramski, U.S. Pat. No. 4,543,865, discloses machining a small groove into part of the sidewall defining the die cavity that provides interference by causing part of the blank or slug formed during stamping to expand into the groove. As a result of the blank or slug expanding into the groove during stamping, pressure between the blank or slug and die land occurs preventing the blank or slug from pulling back through the top of the die and onto the work zone.

What is needed is a machine and method for machining one or more slug keeping grooves or slug retention grooves in a die. What is also needed is a machine and method usable in the field to machine one or more slug keeping/retention grooves in a die without having to remove the die from the stamping press.

SUMMARY

The present invention is directed to a machine for modifying a cavity of a stamping die by forming an elongate slug retention groove in the die that helps prevent pulling of a blank or slug during stamping press operation using the modified die. In a preferred embodiment, the die cavity modifying machine is a portable or transportable slug retention groove forming machine equipped with a base carrying an adjustable carriage which in turn carries a machining head that utilizes a machining insert, preferably a rotary grinding bit, to modify the stamping die to provide slug retention by machining a slug retention groove in a die cavity sidewall of the stamping die. The base of the machine is constructed and arranged to enable the machine to be stably anchored in place during use with a preferred base having a mount configured to releasably yet securely mount the machine on a surface adjacent the stamping die to be modified using the machine.

The carriage of the slug retention groove forming machine is adjustable along a first axis toward or away from the stamping die and the machining head carried by the carriage is adjustable along a second axis generally parallel to a die punch travel direction. The machining head can also be angularly adjustable relative to the carriage and second axis enabling adjustment of the angle of the machining insert, preferably rotary grinding bit, relative to the second axis and the die punch travel direction to help machine a slug retention groove in a stamping die where the groove is oriented at an acute angle relative to the direction of a stamping punch entering the die.

The carriage is movable relative to the base along the first axis preferably in a generally horizontal direction and can extend outwardly from the base beyond the base locating the machining head outwardly of the base. The base carries a first generally horizontal slide arrangement that includes a horizontal slide and drive enables the carriage to move relative to the base along the first or generally horizontal axis. Movement of the carriage generally horizontally relative to the base along the first axis also moves the machining head generally horizontally in unison with the carriage relative to the base along the first axis in a direction toward or away from the stamping die. The drive includes or cooperates with a position indicator that can in the form of a micrometer equipped with a digital display that facilitates precise horizontal positioning of the machining head relative to the stamping die.

The machining head of the slug retention groove forming machine is mounted to the carriage by a second generally vertical slide arrangement with the machining head preferably disposed outwardly of the base by the carriage and movable relative thereto along the second axis in a generally vertical direction enabling positioning of the rotary grinding bit into or out of the die cavity of the stamping die. The machining head preferably also is angularly adjustable to enable adjustment of an angle of the rotary grinding bit relative to the die cavity to enable a slug retention groove to be machined in a die cavity sidewall that is acutely angled relative to the direction of die press movement during stamping operation. Such angular adjustment preferably is provided by a swivel assembly disposed between the machining head and carriage.

The machining head preferably uses a rotary grinder with a machining insert that preferably is a rotary grinding bit to machine the slug retention groove in part of the die cavity defining sidewall of the stamping die. A preferred machining head includes a clamping assembly that releasably clamps the rotary grinder in a manner that permits positioning of the rotary grinding bit of the grinder along the second axis by enabling the grinder to be clamped closer to or farther way from the die. In a preferred embodiment, the rotary grinder is a pencil grinder or micro-grinder and preferably is air or pneumatic powered.

The base of the slug retention groove forming machine includes a mount at enables the machine to be releasably secured to a surface adjacent the stamping die to be modified by machining a slug retention groove in its die cavity defining sidewall. A preferred mount is a magnetic mount used to releasably attach the die cavity modifying machine to a magnetically attractive mounting surface that can be an outer or top surface of the die still mounted in its stamping press or a magnetically attractive workholding surface, such as a workbench or table, located in tool room where the die is being prepared for use in a stamping press. A preferred magnetic mount includes an actuator, such as in the form of a lever or knob, used to magnetically yet releasably attach the mount to the magnetically attractive mounting surface thereby

securely and stably mounting the die cavity modifying machine thereto so its base will not move or slip during operation.

A slug retention groove forming machine constructed in accordance with the present invention preferably is portable, preferably weighing less than 10 pounds, enabling the machine to be transported and used to form a slug retention groove in a cavity of a die while the die is still mounted in its stamping press. Such a slug retention machine enables precise positioning of the machining insert, preferably rotary grinding bit, used to machine the slug retention groove by providing adjustability along a first axis in a direction toward or away from the die as well as adjustability along a second axis toward or away from the cavity of the die in a direction generally parallel to that of a die punch entering the die.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawings illustrate at least one preferred embodiment presently contemplated for carrying out the invention. In the drawings:

FIG. **1** is a front perspective view of a slug retention groove forming machine constructed in accordance with the present invention;

FIG. **2** is a side elevation view of the slug retention groove forming machine;

FIG. **3**A-**3**B are top perspective views of slug retention groove forming machines;

FIG. **4** is a front elevation view of the slug retention groove forming machine;

FIG. **5** is a rear elevation view of the slug retention groove forming machine;

FIG. **6** is a top plan view of the slug retention groove forming machine;

FIG. **7** is a bottom plan view of the slug retention groove forming machine;

FIG. **8** illustrates use of the slug retention groove forming machine on a die already mounted in a stamping press showing the versatility of the machine as it is transportable and usable without having to remove the die from the stamping press;

FIG. **9** illustrates initial positioning of the machine on the die within a stamping press;

FIG. **10** illustrates a slug retention groove machined into the die cavity sidewall using a machining insert of the slug retention groove forming machine that is a grinding bit modifying the die cavity to provide slug retention;

FIG. **11** illustrates use and operation of the slug retention groove forming machine to machine another slug retention groove in a die cavity sidewall of a die cavity of a die insert being modified in a tool room;

FIG. **12** is a fragmentary elevation view of a portion of a die cavity sidewall having a plurality of spaced apart acutely angled slug retention grooves machined into the sidewall using the slug retention groove forming machine shown in FIGS. **1**-**17**;

FIGS. **13**A-**13**H illustrate four different die cavity opening shapes and slug retention groove spacing and placement for each die cavity opening shape;

FIG. **14** is an enlarged view of a portion of the die cavity sidewall of the die cavity of FIG. **13**D;

FIG. **15** is an enlarged fragmentary elevation view of a portion of the die cavity sidewall of FIG. **13**D illustrating the acute angle and length of the elongate slug retention groove machined into the die cavity sidewall using a slug retention groove forming machine constructed in accordance with the present invention;

FIG. **16** is a front perspective view of a slug retention groove forming machine constructed in accordance with the present invention, including inspection, illumination, and contact detecting, systems; and

FIG. **17** is a simplified schematic representation of the contact detecting system of FIG. **16**.

Before explaining embodiments of the invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of the components set forth in the following description and illustrated in the drawings. The invention is capable of other embodiments or being practiced or carried out in various ways. Also, it is to be understood that the phraseology and terminology employed herein is for the purpose of description and should not be regarded as limiting.

DETAILED DESCRIPTION

FIGS. **1**-**7** illustrates a slug retention groove forming machine **20**, also known as a slug keeper machine, constructed in accordance with the present invention used to modify a die cavity or die opening **25** of a die **24** in a manner that helps prevent pulling of blanks or slugs (not shown) created during operation of a stamping press **26** (shown in more detail in FIG. **8**). In the preferred slug retention groove forming machine embodiment shown in FIGS. **1**-**7**, the machine **20** is configured to machine one or more slug retention grooves **22** in a sidewall **27** that forms at least part of a die cavity or opening **25** that help prevent pulling of a slug created during operation of a stamping press **26**. Both the die **24** and the stamping press **26** can be of conventional construction with the die **24** having one or more of a top die shoe, top thrust plate, punch holder plate or punch plate, punch, stripper backing plate stripper plate, die plate, die backing plate lower die shoe and/or guide pillar and brush.

A slug retention groove forming machine **20** constructed in accordance with the present invention is compact, lightweight and therefore advantageously transportable enabling the machine **20** to be used out in the field on a die **24** installed in a stamping press **26** without having to remove the die **24** from the stamping press **26**. The machine **20** is advantageously adjustable along a plurality of axes enabling relatively precise adjustment of a machining head **28** of the machine **20** relative to a die **24** which is going to be modified by machining enabling the depth and angle of each slug retention groove **22** machined into a single die **24** to be precisely controlled.

The slug retention groove forming machine **20** has a base **30** offset from the machining head **28** enabling the machine **20** to stably rest upon the base **30** in a manner that desirably generally positions the machining head **28** relative to a die **24** that is going to be modified using the machine **20** to prevent slug pulling during stamping. The base **30** is constructed and arranged to enable the machine **20** to be stably anchored in place wherever the machine **20** is used. In the preferred slug retention groove forming machine **20** shown in the drawing figures, the base **30** includes a mount **32** configured for releasable mounting on a surface **34**, e.g., a flat or generally planar surface, which can be an outer or top surface of a die **24** mounted in a stamping press **26** or a die resting on a work holding surface of a tool room (not shown) advantageously enabling a preferred embodiment of a slug retention groove forming machine **20** or the present invention to be portable or transportable such that it can be used nearly anywhere.

In one embodiment, the mount **32** is a magnetic mount **36** configured for releasable mounting to a magnetically attractive mounting surface **34** that can be the outer or top surface

of a die **24** mounted in a stamping press **26** or a magnetically attractive workholding surface, e.g., workbench or table, located in a tool room (not shown) where the die **24** is being prepared for use in a stamping press **26**. Such a magnetic mount **36** can include an actuator **38**, such as a lever or knob **40**, used to magnetically yet releasably attach the mount **36** to the magnetically attractive mounting surface **34** securely and stably mounting the machine **20** thereto so its base **30** will not move or slip during operation.

Where the mount **32** is a magnetic mount **36**, the magnetic mount **36** includes a source of magnetic flux (not shown) or magnetic field that emanates from at least a portion of the mount **36**, which can be produced using one or more permanent magnets or by employing one or more electrically energized electromagnets. In one embodiment, one or more permanent magnets, such as one or more rare earth magnets, e.g., Alnico magnets, neodymium magnets, or the like, are disposed within an generally rectangular boxlike outer housing **42** of the magnetic mount **36** and movable relative to the housing **42** toward or away from the magnetically attractive mounting surface **34** in response to manipulation of the actuator **38**. When the magnets of the magnetic mount **36** are moved toward the magnetically attractive outer surface **34**, the magnets are positioned close enough to the surface **34** producing a strong enough magnetic attraction with the mounting surface **34** that immovably anchors the machine **20** in place to the surface **34**. When the magnets of the magnetic mount **36** are moved far enough away from the mounting surface **34** that magnetic attraction with the surface **34** is minimized, the machine **20** can be grasped and lifted free of the mounting surface **34** enabling the machine **20** to be transported elsewhere.

Where the actuator **38** of the magnetic mount **36** is a knob **40**, such as the knob **40** shown in FIG. **5**, the knob **40** can be manually turned or rotated by a user of the machine **20** between a mounting position where the machine **20** is magnetically mounted to a magnetically attractive mounting surface **34** and a release position enabling the machine **20** to be lifted free of the surface **34** and moved to another location. Where the magnetic mount **36** uses one or more electromagnets, the knob **40** can function as a switch or operate a switch that selectively electrically energizes or de-energizes the electromagnets as needed to releasably yet immovably mount the machine **20** to the mounting surface **34**.

The base **30** carries a first slide **44** used to move the machining head **28** along a first axis **45** that preferably is generally parallel to the mounting surface **24** and generally perpendicular or orthogonal relative to a die cavity **25** (FIG. **1**) formed in the die **24** which the slug retention groove forming machine **20** is going to be used to modify to provide slug retention. In the preferred embodiment of the machine **20** shown in the thawing figures, the first slide **44** is a horizontal slide arrangement **46** carried by a base plate **48** that is attached to the mount **32**, such as by one or more fasteners, e.g. bolts, or the like.

With reference to FIGS. **3***a* and **6**, the horizontal slide arrangement **46** includes a drive **49** that moves a slide plate **50** relative to the base **30** enabling the position of the machining head **28** to be moved generally horizontally relative to the base **30** after mounting the slug retention groove forming machine **20** to the mounting surface **34**. The horizontal slide arrangement **46** also includes an anchor plate **52** fixed to the base **30**, such as via one or more fasteners, e.g. bolts, or the like. The drive **49** cooperates with a slide plate stop **54** from which a drive piston or shaft **56** outwardly extends that is attached to the slide plate **50**. The horizontal slide arrangement **46** includes a plurality of spaced apart guides **58**, e.g., elongate guide rods slidably cooperate with the slide plate **50** to slidably guide horizontal movement of the slide plate **50** relative to the base **30**, anchor plate **52**, and slide plate stop **54**.

The drive **49** includes a drive actuator **64** that operatively cooperates with the drive shaft **56** to cause horizontal movement of the slide plate **50** relative to the base **30**, anchor plate **52**, and slide plate stop **54** (and outer surface of a die **24** to which the machine **20** is releasable mounted). In a preferred horizontal slide arrangement **46**, the drive **49** includes or cooperates with a position indicator **66**, e.g., relative position indicator, such as in the form of a micrometer **68** having a digital display **70** capable of displaying relative horizontal slide movement to within 0.0001 inch accuracy enabling precise horizontal positioning of the machining head **28** to be done, in another preferred embodiment, the micrometer **68** enables display of relative horizontal slide movement to within 0.001 inch accuracy enabling slug retention groove depth to be precisely controlled. The micrometer **68** also includes one or more controls **62** that enable a position value to be reset and/or a relative position value to be set during positioning of the machining head **28** using the slide **44**. In a preferred embodiment, the micrometer **68** is a micrometer modified to allow a shaft of the knob **72** to be operatively coupled to the drive shaft **56** while being able to measure movement of the slide plate **50** when the knob **72** is rotated. For example, the shaft of the knob **72** can be directly connected to the drive shaft **56** or indirectly coupled to the drive shaft **56** such as by gearing or the like.

In the preferred slug retention groove forming machine embodiment shown in the drawings, the drive actuator **64** includes a manipulable knob **72** that is rotated in one direction to cause the slide plate **50** to move generally horizontally relative to the base **30**, anchor plate **52**, and slide plate stop **54** in one direction and that is rotated in an opposite direction to cause the slide plate **50** to move generally horizontally relative to the base **30**, anchor plate **52**, and slide plate stop **54** in the opposite direction. Where a manipulable knob **72** is used, rotation of the knob **72** rotates the drive shaft **56** which in turn displaces the slide plate **50** relative to the shaft **56** causing the slide plate **50** to move relative to the base **30**, anchor plate **52** and slide plate stop **54**.

Where the drive **49** employs a rotary drive shaft **56**, the shaft **56** can include or otherwise cooperate with a screw (not shown) disposed in engagement or operative cooperation with the slide plate **50** enabling relative rotation of the shaft **56** to displace the slide plate **50** relative to the shaft **56**. Where a screw type drive arrangement is employed, it can be or otherwise include a ball screw or the like that translates rotation of the drive shaft **56** into relative movement of the slide plate **50** in positioning the machining head **28** generally horizontally relative to a desired die cavity **25** of the die **24** sought to be modified to provide slug retention.

The horizontally displaceable slide plate **50** of the horizontal slide arrangement **46** moves a machining head carriage **74** substantially in unison therewith. The carriage **74** includes a carriage mount **76** carried by the slide plate **50** and a machining head support **78** oriented generally perpendicularly or orthogonally relative to the direction of motion of the horizontal slide arrangement **46**. As is shown in the drawing figures, the machining head support **78** extends generally vertically relative to the slide plate **50** with the carriage mount **76** extending generally outwardly from the machining head support **78** overlying at least a portion of the slide plate **50**.

In the preferred slug retention groove forming machine embodiment shown in the drawing figures, the machining head carriage **74** is generally T-shaped with the carriage mount **76** extending generally horizontally outwardly from a generally vertically extending machining head support **78**. As

is best shown in FIGS. **1**-**3***a*, the carriage mount **76** is a generally rectangular plate that overlaps part of the slide plate **50** with the mount **76** attached to the slide plate **50** using a plurality of fasteners, e.g., bolts, or the like. The machining head support **78** is a generally rectangular plate extending generally perpendicularly or orthogonally to the carriage mount **76**.

The machining head **28** is of adjustable construction being configured to adjustably position a tool **80** of the machining head **28** used to engage and modify the die **24** relative to the die **24**. The machining head **28** is adjustably mounted to the carriage **74** in a manner that permits positioning of the tool **80** along a second axis **79** generally perpendicular or orthogonal to the first axis **45** enabling the tool **80** to be moved relative to the die **24** toward or away from the die **24**. The machining head **28** can also be angularly adjustable enabling a machining bit **82** of the tool **80** to be oriented at an angle, α, relative to the first axis **79** to machine the die **24** at an angle during slug retention die modification.

Where the machining head **28** is angularly adjustable, an angular adjustment mechanism **84** is employed that includes a swivel assembly **86** in operative cooperation with the machining head support **78** that permits swiveling of at least part of the machining head **28** relative to the die **24** to orient the tool **80** at a desired angle, α, before machining the die **24** in performing slug retention modification of the die **24**. The swivel assembly **86** includes a swivel **88** carrying the machining head **28** that is pivotally attached to the machining head support **78** and which can be releasably retained in the desired angular position once the desired angular orientation is set by a user.

As is shown in the drawing figures, the swivel **88** includes an elongate generally vertically extending swivel plate **90** pivotally attached by a pivot **92**, e.g., pivot bolt, to the machining head support **78** at or adjacent one end of the swivel plate **90**. The swivel plate **90** is releasably retained in a desired angular orientation by a swivel clamp **94** that includes an angle adjustment post **96** extending from the swivel plate **90** that is threadably engaged with a clamping knob **98** and tides in an elongate angle adjustment slot **100** (FIG. **5**) formed in the machining head support **78** that can be curved, e.g., arcuate. Although not shown, the angle adjustment mechanism **84** can include a scale or indicator that helps a user of the machine **20** to accurately visually set the angle of the machining insert **82**.

While the angle adjustment slot **100** is formed in the machining head support **78**, the slot **100** can also be formed in the swivel plate **90** if desired. While the pivot **92** is disposed below the slot **100**, it is contemplated that the swivel assembly **86** can be oriented differently, such as by being oriented oppositely with the pivot **92** disposed above the slot **100** such that a modified swivel assembly would be oriented upside down from that shown in the drawing figures.

A second slide **102** carries the machining head **28** enabling movement of the head **28** relative to the die **24** in a direction toward or away from the die **24**. In the preferred slug retention groove forming machine embodiment shown in the drawing figures, the second slide **102** enables the machining head **28** is be moved along, a second axis **79** that is generally perpendicular to the first axis **45** along which the first slide **44** allows machining head movement. In a preferred embodiment, the second axis **79** is generally parallel to the direction a punching die would travel in stamping a slug from a sheet of metal on the die **24** being stamped in the stamping press **26**.

In the preferred embodiment shown in the drawing figures, the second slide **102** is a vertical slide arrangement **104** that includes a slide block arrangement shown in FIGS. **2** and **3***a* as including a lower slide block **106***a* attached to the swivel plate **90** and an upper slide block **106***b* arranged for longitudinal movement with respect to the lower slide block **106***a* and being operably connected to the machining head **28**. This allows the machining head **28** to be movable toward and away from the die **24**. Referring now to FIG. **2**, a damper arrangement **106***c* may be arranged within the second slide **102** for controlling ease of relative movement between the upper and lower slide blocks **106***a*, **106***b*. The damper arrangement **106***c* may include an adjustment screw **106***d* that can be rotated to establish relatively more or less resistance to movement between the upper and lower slide blocks **106***a*, **106***b*. A spring **106***e* may be arranged within the damper arrangement **106***c* to bias the upper slide block **106***a* toward a neutral or upper position relative to the lower slide block **106***b*, for example, in the return spring—type manner. The spring **106***e* may damp or otherwise isolate the machining head **28** from vibrations transmitted through other components of the machine **20**. Rotating the adjustment screw **106***d* may adjust the preload or other characteristic of the spring **106***e* so as to influence the movement resistance between, including optionally locking, the upper and lower slide blocks **106***a*, **106***b*.

Referring again to FIGS. **1** and **2**, movement of the machining head **28** by way of the vertical slide arrangement **104** may be done by directly grasping and manipulating the machining head **28** or by way of a height adjusting arrangement **107**. The height adjusting arrangement **107** may include a position adjustment knob **108** that can be rotated to move the upper and lower slide blocks **106***a*, **106***b* (FIG. **2**) with respect to each other and correspondingly move the machining head **28** close closer to or further from the die **24**. Referring now to FIG. **3***b*, in this embodiment, instead of upper and lower slide blocks **106***a*, **106***b*, the vertical slide **104** includes a slide block **106** extending outwardly from the swivel plate **90** that carries the machining head **28**. The knob **108** of the height adjusting arrangement **107** extends outwardly from the slide block **106** that rotates a gear or toothed shaft (not shown) disposed within the block **106** that engages an elongate linear gear or toothed rack **109** that vertically displaces the head **28** relative toward or away from the die **24**. The rack **109** is mounted to the head **28** or otherwise cooperates with the head **28** in a manner that enables the head **28** to be raised or lowered by turning the position adjustment knob **108**.

The machining head **28** includes a tool clamping assembly **110** having a pair of clamping blocks **112** and **114** attached by fasteners **116**, such as bolts, which can be loosened, such as by using a wrench, e.g., hex head wrench, to change the position of the tool **80** and its machining bit **82** relative to the clamping assembly **110** along with the rest of the machine **20** enabling the position of the insert **82** to be further adjusted relative to the die **24**. Once a desired general position relative to the clamping blocks **112** and **114** has been set, the fasteners **116** are tightened to clamp the blocks **112** and **114** around a housing **118** of the tool **80** securely holding the tool **80** in place. This advantageously enables the general position of the tool **80** and machining insert **82** relative to the die being modified to be generally set before using the machine **20** to actually modify the die to provide slug retention.

As best shown in FIG. **6**, each clamping block **112** and **114** has an elongate and arcuate channel of hemispherical contour or cross section in which a corresponding portion, e.g., half, of the tool housing **118** is received and engaged, represented in dashed-lines extending around the tool housing **118**. As the fasteners **116** are tightened, it increases clamping pressure and friction applied to the tool housing **118** to immovably lock the tool **80** in place. The clamping assembly **110** advan-

tageously enables relatively rough pre-positioning of the machining head **28**, tool **80** and insert **82** relative to the die cavity being, modified before liner position adjustments are subsequently made as described below, which can be made in preparation for slug retention groove forming machine operation as well as during slug retention groove forming machine operation.

In the preferred embodiment of the slug retention slug retention groove forming machine **20** shown in the drawings, the tool **80** is a grinder, such as a fluid powered grinder, which preferably is an air or pneumatic grinder capable of rotating the machining insert **82** at rotational speeds of between zero revolutions per minute and up to 70,000 revolutions per minute during slug retention die modification. The grinder **80** has a generally cylindrical and elongate housing **118** with the machining insert **82** extending outwardly from a chuck or collet **120** at one end and a control **122** at its opposite end adjacent an air hose **124** that supplies motive power to the grinder **80**.

Where the grinder **80** is an air grinder, the control **122** can be a generally cylindrical rotary control carried by the housing **118** that is manually turned in one direction to increase the rotary speed of the machining insert **82** and manually turned in an opposite direction to reduce the rotary speed of the insert **82**, including to stop rotation of the insert **82** when desired. Where the grinder **80** is an air grinder, the grinder speed control **122** preferably controls the flow of pressurized or compressed air from the hose **124** into and through a motor (not shown) within the grinder housing **118** that rotates the insert **82**.

The collet **120** releasably retains the machining insert **82** in a manner that enables removal and replacement of the insert **82** when needed. One or more wrenches **126** releasably mounted using a knob **128** to part of the carriage mount **76** can be removed and used to engage the collet **120** to remove and replace the insert **82**. In the preferred embodiment shown in the drawing figures, the wrench retention knob **128** can either be suitably loosed or disengaged from the carriage mount **76** to enable a pair of wrenches **126** to be removed to be used to engage the collet **120** to change the insert **82**.

In a preferred embodiment, the air grinder **80** is a pencil grinder or micro-air grinder having an elongate generally cylindrical housing **118**, e.g., handle, which has a generally circular cross section or O.D. that is substantially constant along its length enabling the grinder **80** to be clamped in the clamping assembly **110** nearly anywhere along the length of the housing **118**. In one preferred embodiment, the air grinder **80** is a Jet (e.g., Jet JSM-516N), Sioux (e.g., Sioux 5979A), Klatch or Neiko Micro or Pencil Air Grinder having a length of about four to five inches capable of rotating the insert **82** to rotational speeds as fast as 55,000 revolutions per minute. Such an air grinder **80** has a generally cylindrical housing **118** between about two inches and about five inches long, enabling the grinder **80** to be clamped substantially anywhere along the length of its housing **118** providing at least two inches and no more than five inches of adjustment generally in the direction of the second axis **79** prior to performing any further or finer adjustment along the same axis using the vertical slide **104**. This enables the end or tip of the insert **82** to be pre-positioned relative to the die **24** using the clamping assembly **110** before more finely positioning the end or tip of the insert **82** relative to the die **24** using the horizontal and vertical slides **46** and **104**. This enables, for example, macro-positioning of the insert **82** generally in the vertical direction relative to the die **24** before performing finer adjustment in the vertical direction (i.e., generally along axis **79**) using the vertical slide **104** and/or the horizontal direction (i.e., generally along axis **45**) using the horizontal slide **46**.

In a preferred embodiment, the machining insert **82** is a generally cylindrical grinding bit capable of forming a recess, preferably an elongate groove, in part of a die cavity defining sidewall **27** of the die **24**. The machining insert **82** preferably is an elongate generally cylindrical grinding bit that can be a burr-type die grinding bit such as a carbide burr pointed cone die grinding bit, a carbide burr pointed tree shaped die grinding bit, a carbide burr nose tree shaped die grinding bit, a carbide burr cylinder die grinding bit, a carbide burr ball shaped bit, or another suitable burr-type grinding bit. Of course, other types of bits and cutting inserts can be used including an insert **82** having a grinding wheel tip or the like.

Where the die is modified to form a slug retention groove **22** using the machine **20**, such a groove is elongate but relatively shallow having a length extending from at or adjacent the outer surface of the die to below the depth the punch of the stamping presses reaches during stamping of the blank or slug during stamping press operation. The groove that is machined can be straight or helical depending on the contour or configuration of the die cavity. Such a groove can be machined in accordance with that disclosed in U.S. Pat. No. 4,543,865, the entirety of which is expressly incorporated herein by reference. Such a groove formed by the machining insert **82** using the machine **20** can be machined to conform to the specifications and characteristics disclosed in U.S. Pat. No. 4,543,865, but which preferably is substantially straight instead of being helical or spiral.

In use and operation, the tool **80** of the slug retention groove forming machine **20** is positioned on a surface, such as the outer or top surface or a die, e.g., die **24**, where it is readied for use in modifying the die to improve slug retention by machining part of the die in or along a die cavity sidewall **27**. In a preferred method of use, the machine **20** is initially roughly pre-positioned and then more finely adjusted in order to machine part of a die cavity sidewall **27** in a manner that prevents slugs from being pulled out of the die cavity during stamping press operation.

The tool **80** can be positioned to better locate the machining insert **82** relative to a die, e.g. die **24**, being modified by the slug retention groove forming machine **20** by adjusting the position of the tool **80** in the head **28** using the clamping assembly **110**. With reference to FIG. **9**, an Allen wrench is used to loosen the fasteners **116** connecting the clamp blocks **112** and **114** releasing pressure applied by the blocks **112** and **114** to the housing **118** of the tool **80** enabling the housing **118** to be manually grasped to raise or lower the tool **80** and its insert **82**. Once a desired relative machining insert height is set, the Allen wrench is used to tighten the fasteners causing the clamping blocks **112** and **114** to once again clamp tightly around the tool **80** releasably locking it in place. This increased height adjustability advantageously enables the machine **20** to be used to lower the tool **80** and insert **82** enabling the machine **20** to be used to modify a die **24** in a stamping press while the machine **20** is resting on the die **24** as well as to raise the tool **80** and insert **82** enabling the machine **20** to be used to modify a die insert mounted on a surface grinder magnet in a tool room.

FIG. **9** illustrates a pair of wrenches **126** (only one representatively shown) that may be removed from the carriage mount **76** to engage the collet **120** to remove the machining insert **82**, in this case a grinding bit, so it can be replaced. Both wrenches **126** are used to engage different portions of the collet at the same time to loosen the collet **120** enabling the insert **82** to be removed. After removal, another insert **82** is inserted into the collet **120** before the wrenches **126** are used

to re-tighten the collet **120** securing the insert **82** to the collet. The collet **120** can also be loosened to extend or retract the insert **82** relative to the collet **120** and the housing **118** of the tool **80** to change the height of the tip or end of the insert **82** relative to a die or die insert that is going to be modified by the machine **20** to provide slug retention.

FIG. **8** illustrates use of the slug retention groove forming machine **20** in a stamping press **26** with the base **30** of the press resting on the top or outer surface of the die **24** sought to be modified using the machine **20**. FIG. **8** also shows a compressed air hose **124** connected to the tool **80** clamped in the head **28** of the machine **20**. By being small enough to be used within a stamping press **26**, the slug retention groove forming machine **20** advantageously saves time as it allows one or more die cavities formed in the die **24** to be modified using the machine **20** to subsequently provide slug retention when the press **26** is returned to operation. This advantageously enables the die **24** to be modified to provide slug retention without having to pull the die **24** out of the stamping press **26** and taking it to the tool room. This not only saves time and returns the stamping press **26** back to operation faster, it also advantageously enables the slug retention groove forming machine **20** to be used nearly anywhere, on a die in a stamping press, in the tool room on a die being serviced, on a new die before being installed in a stamping press, on takeover dies, as well as on dies that would ordinarily never run without pulling slugs.

FIG. **9** illustrates use of the slug retention groove forming machine **20** being used on a die **24** installed in a stamping press **26** (FIG. **8**). In preparation for use, the machine **20** is placed in the die **24** with its base **30** resting on the outer surface of the die **24**. The base **30** of the machine **20** is manually positioned so it is generally perpendicular to an upper edge of a cavity sidewall **27** of the die **24** that defines a die cavity **25** being modified to provide slug retention. The machine **20** is manually positioned so that its machining insert **82** is located adjacent an upper edge of the die cavity sidewall **27** of the die **24** so that the insert **82** will travel alongside part of the cavity sidewall **27** so that it brushes or touches the sidewall **27** when the tip or end of the insert **82** is lowered into the die cavity. Once this pre-positioning step has been done, the magnetic mount **36** is activated to magnetically mount the base **30** of the machine **20** securely in place on the die **24** so it will not move relative to the die **24** during machining of the die **24** to modify the die **24** to provide slug retention.

With reference again to FIG. **1**, a vertical position of the machining head **28** relative to the die **24** may be adjusted by grasping and manually moving the machining head **28** and/or by rotating the adjustment knob **108** to make sure that the tip or end of the machining insert **82** will pass below the land on the die **24** or die block being modified to provide slug retention. In one preferred method implementation, the machining head **28** is moved to make sure that the tip or end of the machining insert **82** can be extended at least one quarter inch below the outer or top surface of the die **24** or die block. If it cannot be done, the clamping assembly **110** is loosened and the tool **80** is vertically repositioned relative to the clamping assembly **110** to provide the desired amount of machining insert depth in the die cavity.

After that, the tool **80** can be powered to cause the machining insert **82** to rotate. Where the tool **80** is an air grinder, the tool **80** is powered by supplying it with compressed air and by turning the air grinder control **122** to an operating position here compressed air causes the insert **82**, in this case a grinding bit, to rotate.

With continued reference to FIG. **1**, the horizontal slide **46** is manually adjusted by rotating the horizontal position adjustment knob **72** to better position the machining insert **82** relative to an adjacent portion of the die cavity sidewall **27** so that vertical movement of the insert **82** will cause at least a slight groove to be formed in the die cavity sidewall **27**. Once the slight groove is seen in the die cavity sidewall **27**, the micrometer **68** is turned on and set to zero as depicted in FIG. **14**.

With continued reference to FIG. **1** once again, the machining head **28** may be moved up and down by grasping and manually moving the machining head **28** and/or by rotating the knob **108** of the vertical slide **104** to move the machining insert **82** up-and-down to cause the slug retention groove **22** to be machined, in the die cavity sidewall **27** while the knob **72** of the horizontal slide **46** is turned to move the machining insert **82** towards the die cavity sidewall **27** to increase the depth of the groove **22** being machined by the rotating insert **82**.

To control the depth of the groove being, machined by the rotating insert **82**, the digital display of the micrometer **68** is monitored by a user of the machine **20**. In a preferred implementation, a recommended depth of the groove being machined in the die using the rotating insert **82** is about 3% of stamping sheet thickness. To achieve such a depth, the knob **72** of the horizontal slide is rotated after zero setting the micrometer **68** when the insert **82** is initially brushing or contacting the die cavity sidewall **27**. The knob **108** of the vertical slide **104** is rotated to the move the rotating insert **82** up-and-down to further machine the groove in the die cavity sidewall **27** each time the knob **72** of the horizontal slide **46** is rotated. This process is repeated while monitoring the display of the micrometer **68** until a groove depth of the slug retention groove being machined is achieved that is no more than about 5% of stamping sheet thickness and preferably about 3% of stamping sheet thickness.

With reference to FIGS. **1** and **4**, the angle of the rotational or cutting axis **81** (FIG. **4**) of the insert **82** can be varied by adjusting the angle of the tool **80** relative to the vertical axis **79** by an angle, α, which can vary between 0° and 15° which typically can be varied between 0° and no more than about 5° from the vertical axis **79**. To adjust the angle of the tool **80** to change the rotational or cutting axis **81**, the swivel clamping knob **98** is manually loosened to loosen the swivel plate **90** carrying the tool **80**. The swivel plate **90** or head **28** is manually grasped and tilted to orient the angle of the longitudinal axis **81** of the insert **82** at the desired angle, α, relative to the vertical axis **79** before the knob **98** is manually tightened to secure the head **28** carrying the tool **80** along with its insert **82** in place locking it at the desired angle. In the preferred embodiment shown in the drawing figures, the swivel assembly is constructed to enable angular adjustment of the insert **82** within ±5° of the vertical axis **79** (FIG. **4**).

FIG. **10** is illustrates an elongate slug retention groove **22** machined in a die cavity defining sidewall **27** of a die cavity **25** of a die **24** while the machine **20** is secured to the top or upper surface of the die **24** in a stamping press **26** as illustrated in previous drawing figures. The slug retention groove **22** is disposed at an angle that is substantially the same as the angle, α, of the rotational axis **81** of the machining insert **82** relative to a vertical axis **79** that substantially corresponds to the axis of vertical movement of a punch (not shown) that is received in the die cavity **25** formed by the die cavity sidewall **27** of the die **24** machined with at least one groove **22** to provide slug retention. The slug retention groove **22** is disposed at an acute angle relative to the vertical axis **79** that preferably is no more than about 5° relative to the axis **79**.

As is also shown in FIG. **10**, the machining insert **82** is an elongate and generally cylindrical die grinding bit having a grinding surface disposed at or adjacent its free end that forms the slug retention groove **22** by abrading away part of the die cavity sidewall **27** when the machining head **28** is moved up and down by rotating the vertical slide knob **108**. As previously discussed, the horizontal slide position adjustment knob **72** is turned as needed while monitoring the display of the micrometer **68** in order to control the depth of the groove **22** machined by the rotating insert **82**.

During operation, machining head **28** may be moved up and down by grasping and manually moving the machining head **28** and/or by rotating the vertical slide knob **108** one or more times to raise and lower the rotating insert **82** into the die cavity causing the insert **82** to at least begin machining the slug retention groove **22** at the point where the micrometer **68** is set to zero. Thereafter, the horizontal slide position adjustment knob **72** is turned very slightly before the vertical slide position adjustment knob **108** is once again rotated to deepen the depth of the groove **22**. This process is repeated while monitoring the micrometer **68** until the desired groove depth is achieved.

With reference to FIG. **11**, the slug retention groove forming machine **20** can also be used to machine one or more slug retention grooves **22** in a die insert **130**, such as the generally cylindrical or circular die insert **130** shown in FIG. **17**, by securing, the die insert **130** on a flat surface **132** adjacent the machine **20**. A magnetic base or workbench **134** can be employed to hold the insert **130** in place while the above-recited steps are carried out to position the head **28** and hence the groove-machining insert **82** relative to an inner die cavity defining sidewall **136** of the die cavity **138** so that rotation of the groove-machining insert **82** will form a slug retention groove **22** in the inner sidewall **136** of the die insert **130**. After the machine **20** has been used to modify the die insert **130** to provide improved or increased slug retention, the die insert **130** can be removed from the tool room and installed or re-installed in a die or stamping press.

Once again, the machine **20**, head **28** and groove-machining insert **82** are initially pre-positioned (1) so that the groove-machining insert **82** generally brushes against a top portion of the die cavity sidewall **136**, and (2) so that the groove-machining insert **82** travels downwardly into the die cavity **138** far enough to produce a slug retention groove **22** that is long enough. In one preferred method implementation, the machine **20** is setup so that the groove-machining insert **82** will travel downwardly into the die cavity **138** at least as far as the thickness of the sheet that is going to be stamped using the die insert **130**. The angle, α, (FIG. **4**) of the insert **82** is set relative to the vertical axis **79** is set and the micrometer zeroed. Thereafter, the tool **80** is powered to cause the groove-machining insert **82** to rotate before the rotating insert **82** is lowered into the die cavity and subsequently raised as needed by grasping and manually moving the machining head **28** and/or by using the vertical slide knob **108** until a slug retention groove **22** begins forming in the inner die cavity defining sidewall of the die insert. The micrometer **68** is monitored as the horizontal slide knob **72** is turned advancing the insert **82** toward the inner die cavity defining sideman deepening the depth of the slug retention groove being machined by the insert **82**. These method steps are repeated as needed until the slug retention groove forming machine **20** of the invention has machined the slug retention groove **22** having a desired length and depth in the inner die cavity defining sidewall of the die insert. The die insert **130** can be rotated and the above method repeated to machine additional slug retention grooves **22** in the inner die cavity defining sidewall **136** of the die insert **130** as needed. When finished, the slug retention groove modified die insert **130** is installed or re-installed in a die or stamping press ready for stamping press operation.

In practicing the above method of modifying a die cavity in a manner that keeps slugs from pulling from a die during stamping press operation, a slug retention groove forming machine **20** constructed in accordance with the present invention is used to machine a plurality of spaced apart slug retention grooves **22***a*, **22***b*, **22***e*, and **22***d*, in a cavity sidewall **27** of a die cavity or die opening **25** as shown in FIG. **12**. Each groove **22***a*, **22***b*, **22***c* and **22***d* is elongate, substantially straight, and has a length that extends at least to the die land shown in FIG. **12** and preferably at least somewhat just past the die land as shown in FIG. **15**. For example, in one preferred method, the length of each groove **22***a*-**22***d* extends at least one millimeter beyond the die land. Each groove **22***a*-**22***d* preferably has a length that extends from the die cavity mouth at the top surface **34** of the die **24** to beyond the die land as shown in FIG. **12**.

Each groove **22***a*-**22***d* is machined at an acute angle relative to the direction of the punch entering the die, which corresponds to a vertical axis **140** in FIG. **12**. As is shown in FIG. **12**, the grooves **22***a*-**22***d* can be equidistantly spaced apart such that the leading edge of each groove **22***a*-**22***d* originating at or adjacent the die surface **34** (mouth of the die cavity) has substantially equal spacing between adjacent pairs of grooves **22***a*-**22***d*. In a preferred slug retention method, at least a plurality of slug retention grooves **22***a*-**22***b* is machined into the cavity sidewall **27** using the slug retention groove forming machine **20**. In another preferred implementation of a slug retention method according to the present invention, a plurality of pairs of slug retention grooves **22***a*-**22***c* or **22***b*-**22***d* (i.e. at least three slug retention grooves) are machined into the die cavity sidewall **27**. In another preferred method implementation, to or four grooves **22***a*-**22***d* are equidistantly spaced apart and machined into the die cavity sidewall **27** for a given die cavity or die opening **25**.

With continued reference to FIG. **12**, each adjacent pair of grooves **22***a*-**22***b*, **22***b*-**22***c*, and **22***c*-**22***d* is oppositely acutely angled relative to the vertical axis **140** with every other groove alternately acutely angled relative to the adjacent groove. In the exemplary die cavity sidewall shown in FIG. **12**, each slug retention groove has an angle of between 3° and 5° relative to the vertical axis **140** with each adjacent pair of slug retention grooves **22***a* and **22***b*, **22***b* and **22***c*, and **72***c* and **22***d* being oppositely acutely angled at substantially the same acute angle. Machining a plurality of slug retention grooves into the cavity sidewall **27** of a die cavity or die opening **25** advantageously helps keep a slug punched during stamping in the die cavity or die opening **25** so it gets pushed out the bottom end of the die cavity or die opening **25** preventing it from being pulled upwardly out of the die cavity or die opening **25** during stamping press operation.

FIGS. **13**A-**13**H illustrates some exemplary die cavity or die opening configurations along with the placement or location of slug retention grooves, e.g., grooves **22***a*-**22***d* (FIG. **12**), that respectively correspond to numbers **1**-**4** shown in FIGS. **13**A-**13**H. Each die cavity or die opening has either two acutely angled slug retention grooves machined into the die cavity sidewall that defines the die cavity or die opening.

FIG. **14** illustrates an enlarged top view of a slug retention groove **22***a* machined into part of the die cavity sidewall **27** of the oval or oblong die cavity shown in FIG. **13**D. Wherever possible, it is always desirable to minimize the number of slug retention grooves machined into a die cavity sidewall in the part area so it is desired to machine as many slug retention grooves in non-part areas of the die cavity or die opening.

As is shown in FIG. **14**, the groove **22***a* has a relatively shallow depth of no more than 5% of stamping sheet thickness and typically no more than about 3% of stamping sheet thickness. The grinding wheel tip diameter of the machining insert **82** of the slug retention groove forming machine **20** can be chosen based on stamping sheet thickness as is indicated in text in FIG. **14**. In a preferred implementation, the grinding wheel tip of the machining insert **82** of the grinding tool **80** of the slug retention groove forming machine **20** has a diameter no more than 10% of stamping sheet thickness and preferably no more than about 5% of stamping sheet thickness.

Finally, a slug retention groove forming machine **20** constructed in accordance with the invention can also be used to machine an elongate groove in a stripper opening of a die that provides a vent groove shaped the same as the grooves **22** shown in the drawing discussed above that helps reduce suction when the punch is retracting from the die opening or die cavity during stamping press operation. Where the slug retention groove forming, machine **20** is used to machine one or more such vent grooves similar in length and depth as the slug retention grooves **22** shown in the drawing figures discussed above, each vent groove preferably is substantially straight and substantially parallel or coincident with the vertical axis **140** such that it is parallel to the axis along with the punch reciprocates during stamping press operation.

A slug retention groove forming machine **20** or "slug keeper" machine constructed in accordance with the present invention is advantageously versatile in that it is relatively small enabling it to be used to machine slug retention grooves **22** in die cavities or die openings of all shapes, sizes and lengths that can have irregularly shaped opening or cavity shapes or mouths (such as the irregularly shaped cavity/opening **25** of the die **24** shown in FIG. **1**) as well as oblong, square, rectangular, circular, and cylindrical die cavity or die openings of varying lengths, widths and depths. A slug retention groove forming machine **20** constructed in accordance with the present invention is advantageously lightweight and compact having a weight less than ten pounds (about eight pounds) enabling a single person to move, setup and use virtually anywhere including on a die in a stamping press without having to first remove the die. Such a slug retention groove machining machine **20** is also advantageously versatile in that it can be used to machine vent grooves in a stripper opening of a die in a stamping press without having to first remove the die from the stamping press.

Referring, now to FIG. **16** an inspection system **142** may be arranged with respect to the slug retention groove forming machine **20** for enhancing a user's view of the procedure(s) using the slug retention groove forming machine **20**. Inspection system **142** includes an imaging or optical device **144** shown here is a camera **146** although it is understood that in another embodiment, the imaging device or optical device **144** may be a magnifying glass or other imaging/optical device **144**. One preferred imagining or optical device **144** well suited for use in providing a user with an enhanced and/or enlarged image of the portion of the die cavity defining sidewall in which a slug retention groove is going to be machined (as well as during machining of the groove) is a digital microscope that can be a commercially available digital microscope.

The camera **146** includes a lens **148** that may be configured as a magnifying-type lens that is arranged to face toward the machining bit **82** for viewing the engagement of the machining bit **82** with the die **24**. Camera **146** is supported by a support assembly **150** having multiple arms segments **152** that are arranged to articulate with respect to each other and that may be supported by the machine **20** so that the support assembly **150** can articulate with respect to the machine **24** moving the lens **148** to a desired position with respect to the machining bit **82**. The camera **146** preferably is a digital camera, such as a digital camera of a digital microscope, which is operably connected to the display **154** which may be a display **154** of a computer, e.g., tablet, personal computer and/or laptop, and that includes a screen **156** that displays the view provided through the camera **146** and controls **154** manipulating views and/or settings of the camera **146** and/or the screen **156**.

Still referring to FIG. **16**, the machine **20** may include an illumination system **158** having at least one illumination device **160**, shown here as bulbs **162** which may be light emitting diodes. Referring now to FIG. **17**, the bulbs **162** may be spaced from each other and arranged concentrically around the tool **80** which may provide full illumination around the tool and the machining bit **82**, without presenting shadows in any direction. Still referring to FIG. **17**, a contact detecting system **164** may be arranged to detect and indicate an occurrence of the machining bit **82** contacting the die **24**, both shown schematically in FIG. **17**. The contact detecting system **164** may include conductors **166** such as wires or other electrical conducting arrangements that operably connect the machining bit **82** and die **24** to the power source **168** which may include a battery or other source of electrical energy. A contact switch **170**, schematically represented as a dashed circle, may be defined by the machining bit **82** and die **24** that are arranged within a common circuit **172** so that the engagement or disengagement of the machining bit **82** and die **24** acts as a switch that closes or opens the circuit **172**, respectively. Closing the circuit **172** during the engagement of the machining bit **82** and die **24** energizes a contact indicator **174** in a manner that is recognizable by the user of machine **20** (FIG. **1**), allowing the user to recognize when the machining bit **82** first contacts the die **24**. In this embodiment, the contact indicator **174** may be defined at least partially by the illumination system **158**. Initial contact between the machining bit **82** and the die **24** causes the illumination device (s) **160** to illuminate. In one embodiment, some of the illumination device(s) **160** may be illuminated before initial contact between the machining bit **82** and the die **24** and when the machining bit **82** contacts the die **24** the remaining illumination device(s) **160** may illuminate so as to provide a visual indication to the user by way of a relatively brighter or more intense light from the illumination system **158** that the machining bit **82** has contacted the die **24**.

The present invention therefore is directed to a machine **20** for modifying a die **24** to provide slug retention that includes a base **30**, a carriage **74** adjustable along a first axis relative to a die **24**, and a machining head **28** adjustable along a second axis relative to a cavity in the die **24**. The carriage **74** is adjustable along a first axis that is generally perpendicular to the direction of a punch traveling into the cavity of the die **24** during stamping. The machining head **28** is adjustable along a second axis generally parallel to the direction of a punch traveling into the cavity of the die during stamping. The machining head **28** is adjustable along a second axis generally parallel to the direction of a punch traveling into the cavity of the die during stamping preferably by adjusting or enabling adjustment of the position of the head **28** relative to the die **24** and/or the die cavity **25**. The machining head **28** is angularly adjustable to adjust the angle of the machining insert **82** relative to the second axis and die punch travel direction. The machining head **28** is angularly adjustable to adjust the angle of the machining insert **82** relative to the second axis and die punch travel direction thereby enabling adjustment of the

angle of a slug retention groove **22** formed in a die cavity **25** defining sidewall **27** relative to the die cavity defining sidewall.

The head **28** preferably carries a rotatable machining insert **82** or tool used to modify a cavity **25** of a die **24** to prevent blank or slug pulling during stamping press operation. A preferred the machining insert **82** is a rotary grinding bit such as a rotary grinding bit of a grinder or die grinder with the bit being used to machine or otherwise form an elongate slug retention groove **22** in part of a die **24** disposed in a cavity **25** in the die **24** that preferably is a die cavity **25** defining sidewall **27** that forms at least part of the die cavity **25**. The grinder **80** is mounted in a clamping assembly **110** that permits movement of the grinding bit **82** along the second axis by loosening the clamping assembly **110**, moving the grinder **80** within the clamping assembly **110**, and then tightening the clamping assembly **110**. The grinder **80** is mounted in the clamping assembly **110** in a manner that permits movement of a tip of a grinding bit **82** of the pencil grinder or micro-grinder along the second axis relative to the die enabling the tip of the grinding bit **82** to be moved closer to the die or farther away from the die **24**. The grinder **80** preferably is a pencil grinder or micro grinder that can be pneumatically powered.

The clamping assembly **110** can be formed of a plurality of clamping blocks in which the grinder **80** is releasably clamped therebetween in a manner that enables the position of the grinder **80** and its grinding bit generally along the second axis relative to the die enabling the position of the grinding bit **82** to be adjusted relative to a cavity of the die in which a slug retention groove **22** is going to be formed.

The machine **20** can have a position measurement device **66** in operable cooperation with the carriage **74** and/or generally horizontal slide to enable a position of the carriage **74** as well as the grinding bit **82** relative to the die cavity **25** to be monitored and/or set. The position measurement device **66** can include a display **70** to provide position feedback to a user during positioning of the grinding bit **82** relative to the die cavity **25** in preparation for slug retention groove **22** formation. One preferred position measurement device **66** is a micrometer configured to enable the magnitude of movement of the carriage **74** along the generally horizontal or first axis to be set, monitored and/or displayed during carriage **74** movement. The position measurement device **66** has a manipulable actuator that causes movement of the carriage **74** along the slide when manipulated by as user enabling relatively precise positioning of the cutting, bit **82** relative to the die cavity **25** defining sidewall **27** in which the slug retention groove **22** is going to be machined. One preferred micrometer is a depth micrometer with the micrometer having a knob **72** that is manipulated by a user to move the carriage **74** along the slide to position the cutting bit **82** relative to the die cavity **25** defining sidewall **27**.

The machine **20** is portable and lightweight having a weight less than ten pounds. The machine **20** has a magnetic base **30** enabling the machine **20** to be mounted in nearly any position including within a die in a stamping press **26**. The machining head **28** preferably includes an illumination arrangement **158** such as one formed of lights, such as LED lights, arranged around the grinder clamping in the clamping assembly **110** of the head **28** to illuminate the part of the die **24** and die cavity **25** defining sidewall **27** in which a slug retention groove **22** is being machined and during machining of the slug retention groove **22**. The machining head **28** can carry or serve as a mount for an imaging device that enables a user to better or more clearly see the portion of the die cavity **25** and the die cavity **25** defining sidewall **27** in which a slug retention groove **22** is going to be machined prior to and during machining of the groove **22**. A preferred imaging device **160** includes a camera that preferably is a digital camera capable of being linked to another device, such as a display screen, tablet, personal computer, smart phone, or the link, such as via a USB, Bluetooth, Wi-Fi or other type of wired/wireless link.

One preferred embodiment of a machine **20** for modifying a die **24** to provide slug retention includes a magnetic base **30**, a carriage **74** comprised of (a) a generally horizontal slide enabling movement of the carriage **74** relative to a cavity **25** in the die **24** along a generally horizontal axis, and (b) a carriage position measurement device **66** enabling measurement of a change in position of the carriage **74** during movement of the carriage **74** along the first slide **44** and having a manipulable actuator that is manipulable to change the position of the carriage **74** by moving the carriage **74** along the first slide **44**; and a machining head **28** that includes an angularly adjustable rotary cutting bit **82** and a generally vertical slide **104** enabling movement of the machining head along a generally vertical axis relative to a die cavity **25** of the die **24** in machining a slug retention groove **22** in a portion of the die disposed in the die cavity.

Understandably, the present invention has been described above in terms of one or more preferred embodiments and methods. It is recognized that various alternatives and modifications may be made to these embodiments and methods, which may include alternative combinations of two or more of the individual features mentioned from the same or different drawings or as otherwise evident from the text and/or drawings, and which are within the scope of the present invention.

What is claimed is:

1. A machine for modifying a die to provide slug retention comprising:

a magnetic base that enables the machine to be removably attached to a magnetically attractive surface;

a carriage adjustable along a first axis; and

a machining head comprising a machining insert used to modify the die to provide slug retention, the machining head carried by the carriage and adjustable along a second axis.

2. The machine of claim **1** wherein the machining head comprises a tool holder that releasably holds a machining tool to which the machining insert used to modify a cavity of the die to prevent blank or slug pulling during stamping press operation is mounted.

3. The machine of claim **1** wherein the machining head comprises a clamp that releasably clamps a rotary grinder, and wherein the machining insert is a rotary grinding bit mourned to the rotary grinder.

4. The machine of claim **1** wherein the carriage is cantilevered from the base disposing the machining head outwardly of the base, wherein the carriage is movable relative to the base along the first axis moving the machining head therewith, the first axis generally perpendicular to the direction of a punch traveling into the cavity of the die during stamping, and wherein the machining head is movable relative to the carriage and base along the second axis, the second axis generally parallel to the direction of the punch traveling into the cavity of the die during stamping.

5. The machine of claim **1** wherein the machining head is disposed outwardly of the base and movable relative to the carriage along the second axis generally parallel to a direction of a punch traveling into the cavity of the die during stamping moving the machining insert relative to the carriage and second axis toward or away from the die being modified to provide slug retention.

6. The machine of claim 5 wherein the machining head is angularly adjustable relative to the carriage and second axis to adjust the angle of the machining insert relative to the second axis and die punch travel direction.

7. The machine of claim 6 wherein the machining insert is a rotary grinding bit that machines an elongate slug retention groove into a die cavity defining sidewall that forms at least part of the cavity of the die that is oriented at an acute angle relative to the direction of the punch traveling into the die cavity during stamping.

8. The machine of claim 1 further comprising a first slide enabling adjustment of the carriage relative to the base along the first axis moving the machining head toward or away from a die cavity defining sidewall of a die cavity formed in a stamping die and a second slide enabling movement of the machining head relative to the carriage and base along the second axis into or out of the die cavity formed in the stamping die.

9. The machine of claim 8 further comprising a micrometer in operable cooperation with the first slide enabling the magnitude of movement of the carriage along the first axis to be displayed during carriage movement.

10. The machine of claim 9 further comprising an actuator in operable cooperation with the micrometer and the first slide, and wherein manipulation of the actuator causes the first slide to move the carriage along the first axis.

11. The machine of claim 10 wherein the actuator comprises a manipulable knob of the micrometer.

12. A machine for modifying a die to provide slug retention comprising:

a base that substantially immovably fixes the machine in place relative to the die;

a carriage carried by the base, the carriage comprised of (a) a carriage mount carried by a first slide enabling movement of the carriage relative to a cavity in the die along a first axis that is generally parallel to a surface of the die, and (b) a machining head support carried by the carriage mount, the carriage mount extending outwardly beyond the base disposing the machining head support outwardly of the base; and

a machining head carried by the machining head support and disposed outwardly of the base, the machining head comprised of (a) a machining tool having a rotary cutting bit with a cutting axis about which the rotary cutting bit rotates, and (b) a second slide enabling movement of the machining head and rotary cutting bit relative to the carriage along a second axis that is generally perpendicular to the first axis toward or away from a die cavity of the die in machining a slug retention groove in a portion of the die disposed in the die cavity; and

wherein the machining tool is angularly adjustable relative to the second axis enabling the cutting axis of the rotary cutting bit of the machining tool to be oriented at an acute angle relative to the second axis.

13. The machine of claim 1 further comprising an angular adjustment arrangement enabling adjustment of the angle of the machining head relative to the second axis.

14. The machine of claim 13 wherein the angular adjustment arrangement comprises a swivel assembly in operable cooperation with the machining head enabling angular adjustment of a rotational axis of the machining insert relative to the second axis.

15. The machine of claim 14 wherein swivel assembly comprises a swivel plate carrying the machining head that is attached to the carriage by a pivot and a manipulable swivel plate clamping knob that rides in an elongate angle adjustment enabling slot formed in the carriage.

16. The machine of claim 15 wherein the swivel assembly enables angular adjustment of the rotational axis of the cutting insert to an angle formed between the cutting insert rotational axis and second axis that is within ±15 degrees of the second axis.

17. The machine of claim 1 wherein the carriage is extends outwardly from the base beyond the base, the carriage movable relative to the base along the first axis in a generally horizontal direction, and wherein the machining head is mounted to the carriage and disposed outwardly of the base, the machining head movable along the first is in a generally vertical direction.

18. The machine of claim 1 wherein the machining insert comprises a rotary grinding bit, and wherein the machining head comprises a pencil grinder or micro-grinder mounted in a clamping assembly that permits movement of the grinding bit along the second axis by enabling the pencil grinder or micro-grinder to be clamped by the clamping assembly closer to or farther away from the die.

19. The machine of claim 12 wherein the carriage is cantilevered outwardly from the base with the machining head disposed at an end of the carriage, wherein the machining head is adjustable along the second axis by moving the machining head relative to the carriage along the second axis, wherein the machining insert comprises a cutting bit rotatable about an axis of rotation, and wherein the machining head is angularly adjustable relative to the second axis and the carriage adjusting the angle of the machining insert axis of rotation relative to the second axis.

20. The machine of claim 1 wherein the slug retention machine is transportable enabling the slug retention machine to be used to modify a die in a stamping press or a die disposed in a tool room.

21. The machine of claim 12 wherein the carriage is generally T-shaped with (a) the carriage mount extending generally horizontally and overlying the base, and (b) the machining head support extending generally vertically from a free end of the carriage mount, and wherein the machining head is mounted to the machining head support, the machining head extending generally vertically.

22. The machine of claim 1 wherein the machine is portable and weighs less than 10 pounds.

23. The machine of claim 12 wherein the machine is portable and weighs less than 10 pounds.

24. The machine of claim 12 wherein the carriage further comprises a carriage position measurement device having a display.

25. The machine of claim 12 wherein the base comprises a magnetic base.

26. A machine for modifying a die to provide slug retention comprising:

a magnetic base;

carriage comprised of (a) a generally horizontal slide enabling movement of the carriage relative to a cavity in the die along a generally horizontal axis, and (b) a carriage position measurement device enabling measurement of a change in position of the carriage during movement of the carriage along the first slide and having a manipulable actuator that is manipulable to change the position of the carriage by moving the carriage along the first slide; and

a machining head comprised of an angularly adjustable rotary cutting bit and a generally vertical slide enabling movement of the machining head along a generally vertical axis relative to a die cavity of the die in machining a slug retention groove in a portion of the die disposed in the die cavity.

27. The machine of claim 26 wherein the machining head comprises a tool holder removably holding a rotary grinder that rotates the rotary cutting bit, the rotary grinder movable relative to the machining head along the vertical axis.

28. The machine of claim 26 wherein the machining head comprises a tool clamping assembly releasably holding a pneumatically powered pencil or micro-air grinder, the rotary cutting bit mounted to the grinder.

29. The machine of claim 26 wherein the carriage extends outwardly beyond the base disposing the machining head outwardly of the base, and wherein the vertical slide is configured to enable movement of the machining head relative to the base and carriage along the vertical axis.

30. The machine of claim 26 wherein the carriage comprises (a) a generally horizontally extending carriage mount overlying the base extending generally horizontally outwardly beyond the base, and (b) a generally vertically extending machining head support to which the machining head is angularly adjustably mounted, the machining head support carried by the carriage mount and disposed outwardly of the base disposing the machining head outwardly of the base.

31. The machine of claim 26 wherein the position measurement device comprises a micrometer.

32. The machine of claim 26 further comprising a light illumination system that illuminates the rotary cutting bit and an imaging device that enables a user to see the cutting bit.

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UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 9,149,902 B2
APPLICATION NO. : 13/828399
DATED : October 6, 2015
INVENTOR(S) : DeCore et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Claims

In Claim 3, Column 18, Line 50, replace "mourned" with -- mounted --.

In Claim 17, Column 20, Line 6, replace "carriage is extends" with -- carriage extends --.

In Claim 17, Column 20, Line 11, replace "along the first is in" with -- along the first axis in --.

Signed and Sealed this
Eighth Day of March, 2016

Michelle K. Lee

Michelle K. Lee
Director of the United States Patent and Trademark Office